

# A Guide to Understanding POF

## APPLICATIONS:

- Home networking
- Industrial
- Medical
- Avionics
- Automotive

By: Francesco Liburdi

2 Sep. 2013      Initial release

**Electronic Links International, Inc. assumes no responsibility for inaccuracies or omissions in the information contained in this document. Specifications are subject to change without notice. Additional information about Electronic Links International, Inc. is available at [www.electronic-links.com](http://www.electronic-links.com)**

## Table of Contents

A Guide to Understanding POF.....	1
Table of Contents.....	2
Table of Figures.....	2
Understanding POF.....	3
Future speeds of wired infrastructure.....	3
ELII Conclusion.....	4
The infrastructure in the United States vs other countries .....	4
Who is wired?.....	5
Who is Wireless? .....	6
Ethernet.....	7
Cat5e and Cat6 Comparison.....	8
Category 6 Cable Questions.....	9
Category 6 Connecting Hardware Questions.....	10
Differences between Plastic and Glass Fiber.....	11
Benefits of POF.....	12
ELII products for Home Networking.....	13-14-15
A typical Suite Design Floor plan for Optical POF Wire and Wireless solutions....	16
ELII products for industrial, medical, automotive, and avionics.....	17-18

## Table of Figures

Figure 1: Data provided by OECD for Wired Networks.....	5
Figure 2: Data provided by OECD for Wireless.....	6
Figure 3: Single-Mode, Multi-mode and POF Fiber Core / Cladding Diameters.....	12
Figure 4: Typical Suite.....	16

## Understanding POF

### ***Future speeds of wired infrastructure***

Given the limitations of the end to end equipment we can see a comparison of rated wired speeds carried over the wired network typically listed by a manufacture of CAT copper wire. The actual speeds achieved are depended on the actual Ethernet card and switch / router. For example a 1Gig Ethernet card and 1 Gig switch is not likely to surpass 133 Mhz on a CAT 5 cable, 200 Mhz on a Cat 5e cable, and 250Mhz on a Cat6, 350 Mhz on a Cat6e.

CAT 5E	100 MHz	100 Mbps TPDDI 155 Mbps ATM Gigabit Ethernet. Offers better near-end crosstalk than CAT 5
CAT 6	Up to 250 MHz	Minimum cabling for data centers in TIA-942. Quickly replacing category 5e.
CAT 6E	Up to 500 MHz (field-tested to 500 MHz)	Support for 10 Gigabit Ethernet (10GBASE-T.) May be either shielded (STP, ScTP, S/FTP) or unshielded (UTP). This standard published in Feb. 2008. Minimum for Data Centers in ISO data center standard.
CAT 7 (ISO Class F)	600 MHz 1.2 GHz in pairs with Siemon connector	Full-motion video Teleradiology Government and manufacturing environments Fully Shielded (S/FTP) system using non-RJ45 connectors but backwards compatible with hybrid cords. Until February 2008, the only standard (published in 2002) to support 10GBASE-T for a full 100m.

Manufactures will rate their cables as follows “rated up to”

- CAT-5 is rated to 100Mhz
- CAT-5e is rated to 350Mhz
- CAT-6 and CAT6e is rated to 550Mhz or 1,000Mhz depending on your source
- CAT-6a is rated to 750Mhz
- CAT-7 not supported as a standard.



**POF - is rated to 1,250Mhz, and can handle in the test lab up to 2,500Mhz.**

Note: The translation of 100Mhz is equal to 100Megbytes (Mb).

Note: POF 2011 ELII Optical POF Switch and Wall Plate Converter is commercially available for 100Mb Ethernet with rates up to 250Mhz. Production for commercially available products are being tested using the existing POF cabling of up to 50 meters for 1,000mb or 1G Ethernet and is expected to be available commercially for the 1st quarter 2014.

## **ELII Conclusion**

Installing POF cabling today is clearly the better choice for networking with infrastructure runs of up to 80 meter connecting to a POF switch and wall plate converters. It is ideal for business, home, student housing, apartments, and condos. With future component upgrades anticipated, the cost, the benefits and choice of POF wire is clear. The current optical POF wired infrastructure will support higher bandwidths demands projected for the average user of 2020 and beyond without changing the cabling. With conventional CAT copper solutions wiring infrastructure would have to be changed POF does not.

## **The infrastructure in the United States vs other countries**

The United States is by far the largest user of wired and wireless networks. Using the Organization for Economic Co-operation and Development (OECD) data some predictions can be reasonably developed on bandwidth needs.

## Who is Wired?

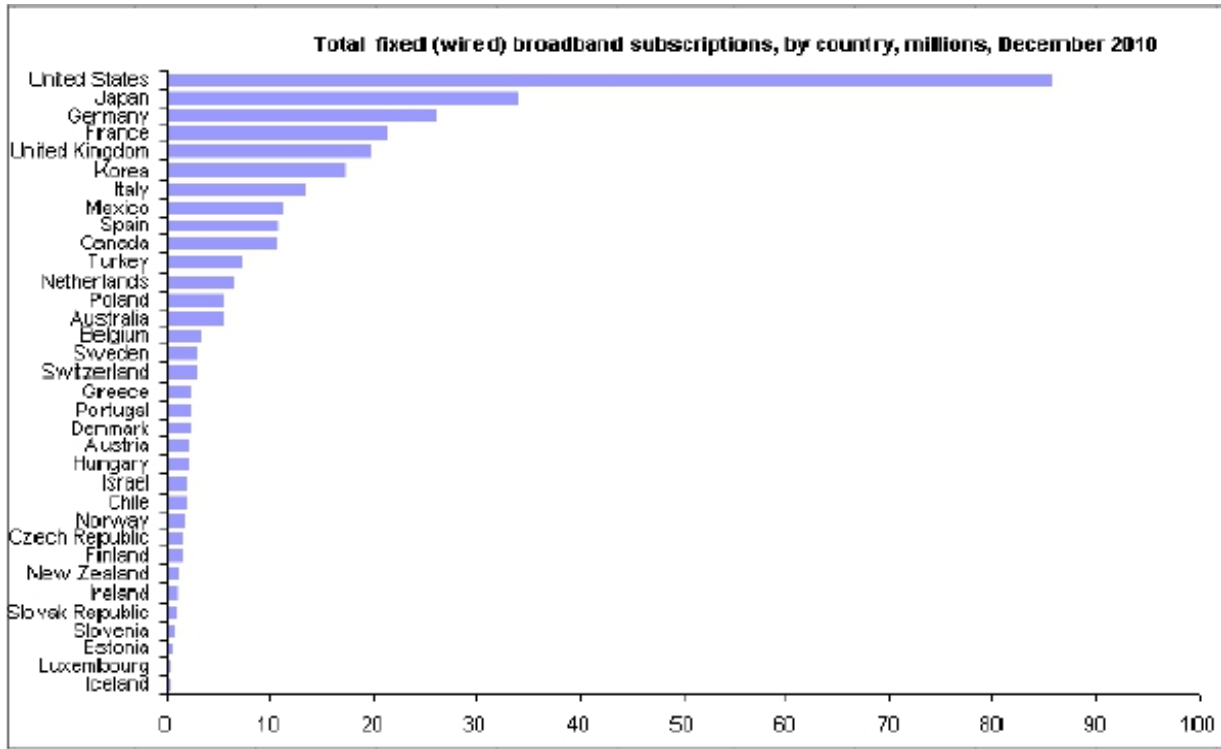


Figure 1: data provided by OECD for Wired Networks

## Who is Wireless?

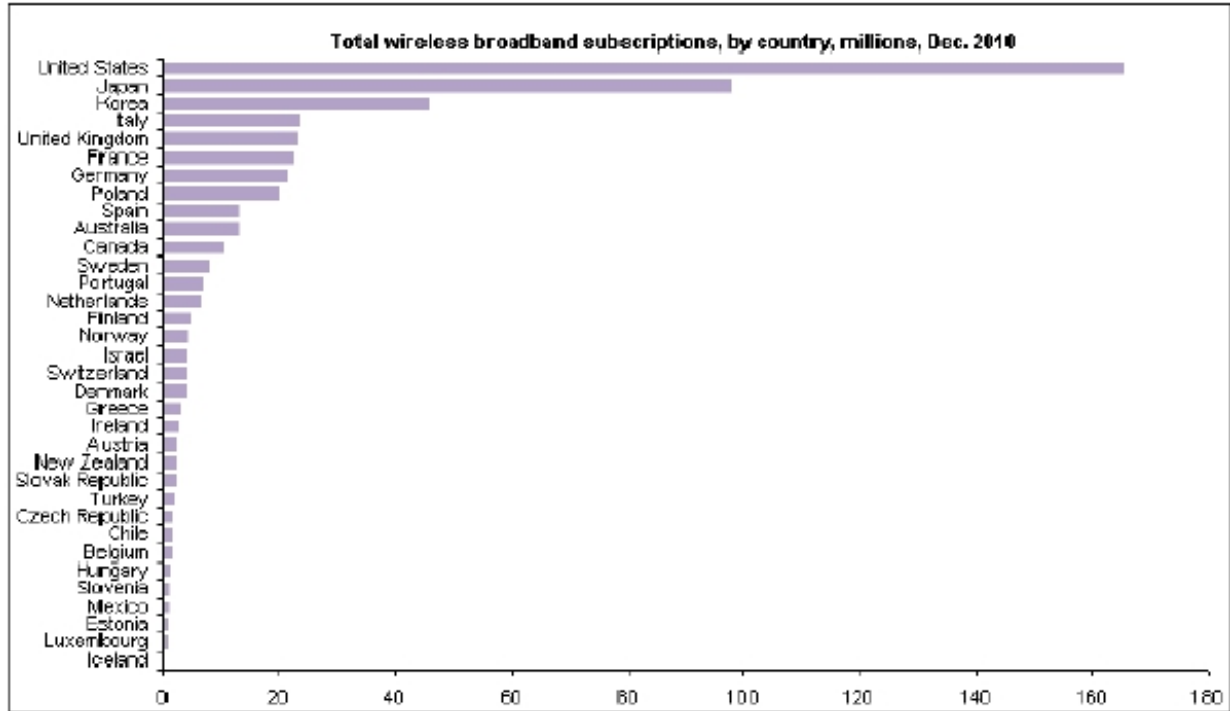


Figure 2: data provided by OECD for Wireless

## Estimates of future per user bandwidth for “High End Users” 2010 – 2020

Using Nielsen’s law, we have extrapolated the domestic US available bandwidth per end user based on the law’s original precept: that the bandwidth available to a high end-user will increase by 50% per year.

Year Rate Scale	
2010	51 Mbps
2011	77 Mbps
2012	115 Mbps
2013	173 Mbps
2014	259 Mbps
2015	388 Mbps
2016	582 Mbps
2017	873 Mbps
2018	1,310 Mbps
2019	1,153 Mbps
2020	1,965 Mbps

Table 1 – High end US User extrapolation

As shown 100 Megabit per second per user demands are exceeded by 2012, and Gigabit per user demands by 2018.

In the next table, the average US speed quoted in the 2010 OECD report of approximately 14 Megabits per second per user,

Year Rate Scale	
2010	14 Mbps
2011	21 Mbps
2012	31 Mbps
2013	47 Mbps
2014	71 Mbps
2015	106 Mbps
2016	159 Mbps
2017	239 Mbps
2018	359 Mbps
2019	538 Mbps
2020	807 Mbps

Table 2 – Average US User extrapolation

In this table 100 Megabit per second per user demand is reached in 2015, and Gigabit beyond 2020.

## ***Ethernet***

### **Cat5e and Cat6 Comparison**

#### **Why do I need all the bandwidth of category 6?**

Bandwidth precedes data rates just as highways come before traffic. Doubling the bandwidth is like adding twice the number of lanes on a highway. The trends of the past and the predictions for the future indicate that data rates have been doubling every 18 months. Current applications running at 1 Gb/s are really pushing the limits of category 5e cabling. As streaming media applications such as video and multi-media become commonplace, the demands for faster data rates will increase and spawn new applications that will benefit from the higher bandwidth offered by category 6. This is exactly what happened in the early 90's when the higher bandwidth of category 5 cabling compared to category 3 caused most LAN applications to choose the better media to allow simpler, cost effective, higher speed LAN applications, such as 100BASE-TX. Note: Bandwidth is defined as the highest frequency up to which positive power sum ACR (Attenuation to Crosstalk Ratio) is greater than zero.



### **What is the general difference between category 5e and category 6?**

The general difference between category 5e and category 6 is in the transmission performance, and extension of the available bandwidth from 100 MHz for category 5e to 200 MHz for category 6. This includes better insertion loss, near end crosstalk (NEXT), return loss, and equal level far end crosstalk (ELFEXT). These improvements provide a higher signal-to-noise ratio, allowing higher reliability for current applications and higher data rates for future applications.

### **Will category 6 supersede category 5e?**

Yes, analyst predictions and independent polls indicate that 80 to 90 percent of all new installations will be cabled with category 6. The fact that category 6 link and channel requirements are backward compatible to category 5e makes it very easy for customers to choose category 6 and supersede category 5e in their networks. Applications that worked over category 5e will work over category 6.

### **What does category 6 do for my current network vs. category 5e?**

Because of its improved transmission performance and superior immunity from external noise, systems operating over category 6 cabling will have fewer errors vs. category 5e for current applications. This means fewer re-transmissions of lost or corrupted data packets under certain conditions, which translates into higher reliability for category 6 networks compared to category 5e networks.

### **When should I recommend or install category 6 vs. category 5e?**

From a future proofing perspective, it is always better to install the best cabling available. This is because it is so difficult to replace cabling inside walls, in ducts under floors and other difficult places to access. The rationale is that cabling will last at least 10 years and will support at least four to five generations of equipment during that time. If future equipment running at much higher data rates requires better cabling, it will be very expensive to pull out category 5e cabling at a later time to install category 6 cabling. So why not do it for a premium of about 20 percent over category 5e on an installed basis?

### **Is there a use for category 6 in the residential market?**

Yes, category 6 will be very effective in the residential market to support higher Internet access speeds while facilitating the more stringent Class B EMC requirements (see also the entire FCC Rules and Regulations, Title 47, Part 15). The better balance of category 6 will make it easier to meet the residential EMC requirements compared to category 5e cabling. Also, the growth of streaming media applications to the home will increase the





need for higher data rates which are supported more easily and efficiently by category 6 cabling.

### **Why wouldn't I skip category 6 and go straight to glass optical fiber?**

You can certainly do that but will find that a fiber system is still very expensive. Ultimately, economics drive customer decisions, and today optical fiber together with optical transceivers is about twice as expensive as an equivalent system built using category 6 and associated copper electronics. Installation of copper cabling is more craft-friendly and can be accomplished with simple tools and techniques. Additionally, copper cabling supports the emerging Data Terminal Equipment (DTE) power standard under development by IEEE (802.3af).

### **Why wouldn't I skip category 6 and go straight to POF optical fiber?**

Yes, POF is comparable to the cost of Cat 5e or Cat 6e install using the ELII solution . there is a cost advantage for actual install time, is eye safe and requires less power as well as other advantages, including no cross talk if installed next to electrical wires.

## **Category 6 Cable Questions**

### **What is the difference between enhanced category 5e cable rated for 400 MHz and category 6 cable rated for 250 MHz?**

Category 5e requirements are specified up to 100 MHz. Cables can be tested up to any frequency that is supported by the test equipment, but such measurements are meaningless without the context of applications and cabling standards. The category 6 standard sets minimum requirements up to 250 MHz for cables, connecting hardware, patch cords, channels and permanent links, and therefore guarantees reasonable performance that can be utilized by applications.

## **Category 6 Connecting Hardware Questions**

### **Are the connectors for category 5e and category 6 different? Why are they more expensive?**

Although category 6 and category 5e connectors may look alike, category 6 connectors have much better transmission performance. For example, at 100 MHz, NEXT of a category 5e connector is 43 decibels (dB), while NEXT of a category 6 connector is 54 dB. This means that a cat6 connector couples about 1/12 of the power that a cat5e connector couples from one pair to another pair. Conversely, one can say that a category 6 connector is 12 times less "noisy" compared to a category 5e connector. This vast improvement in performance was achieved with new technology, new

processes, better materials and significant R&D resources, leading to higher costs for manufacturers.

Unshielded Twisted Pair (UTP) Cat6 is the most common category 6 data cable. Despite the name, it offers superior data transmission, signal integrity and resistance to RF/EMI due to its tightly wound twisted pair configuration. Shielded (STP) CAT6 cable is used in special applications. Cat6E is a designation used by some manufacturers to show that the cable far surpasses the cat6 requirements. Augmented Cat6A however is a standard, Cat6A cable supports 10G (10xGigabit) ethernet over copper. When Cat5E or Cat6 is specified, use Cat6E for future-proofing at a very low price differential. Cat6A is the most advanced cable reserved for very high performance requirements over copper. Cat6A cable is usually 50% thicker than a typical Cat6 cable.

**Cat6, Enhanced Cat6(Cat6e) and Augmented Cat6(Cat6A) Bulk Cable**

Although Category 6 cable bandwidth is limited to 200MHz a good quality Cat6 cable is tested far beyond the standards requirement. A quality Category 6 cable offers high signal-to-noise and high transmission reliability. Key performance indicators are low insertion loss, near end cross talk (NEXT), equal level far end cross-talk (E-FLEXT). For high density installations Alien cross-talk is another important characteristic that needs to be managed.

Enhanced Cat6 or Cat6E cables are tested well beyond the category 6 requirements. These cables have better after-the-install performance characteristics. Cat6E cables are well suited for challenging physical, EMI, and high density installation environments. Augmented Cat6, or Cat6A cables are currently the highest rated twisted pair cable standard. Cat6A supports high-speed data applications like 10-Gigabit Ethernet. Cat6A cables offer true multi-media capabilities and are rated for performance up to 750MHz.

Select from our premier collection of Cat6/Cat6E/Cat6A bulk cable for plenum and non-plenum applications. Residential installation require UL-rated(non- plenum) cables. The PVC (non-plenum) cables we offer exceed the UL requirements. Most commercial/office installations require plenum rated cable.

Performance	Applications	When to use	Where to use	Advantage
Cat6 - Good	Gigabit Ethernet(GigE)	Use this when Cat5e is specified	residential & office networks	Future-proof Cat5e installs
Cat6E - Better	Gigabit Ethernet(GigE), PoE, ATM, Video	Multi-media applications, noisy environments,	workstation connectivity, network backbone,	Less susceptible to outside interference

		PoE Support	IEEE 802.11 a/b/g uplink, digital studios, hospitals, labs, datacenters	
Cat6A - Best	10 Gigabit Ethernet(10GigE)	Highest available Performance	Data centers, labs, cluster computing, IEEE 801.11 a/b/g & n uplink	Alien cross-talk performance in high density applications

***Differences between Plastic and Glass Fiber***

POF differs from traditional optical fiber in material and the core / cladding dimensions. The core is the highly refractive center of the fiber which acts as a 'light guide'. For standard telecommunication Single-Mode Fiber (SMF), the core diameter is around 9um and the cladding diameter 125um. SMF is utilized in long haul applications with transmission distances of up to 100km, without the need for any repeater. Multi-Mode Fiber (MMF) uses a core / cladding diameter of typically 50um / 125um, providing less reach, up to approximately 2km, due to increased dispersion as a consequence of the larger diameter core. POF has a much larger core diameter compared to both SMF and MMF, commonly 980um / 1000um. Although this results in lower data rates (hundreds of Mbps) and reach, the big advantage is cost. The large core means the accuracy of alignment between the LED driver and fiber is less critical, to a point where even slightly damaged fiber is acceptable. Most of the expense in fiber systems today is not in the BOM (Bill of Materials) but production set up and alignment costs. The core / cladding diameters of Single-Mode, Multi-Mode and POF fiber are depicted in Figure 1 below.

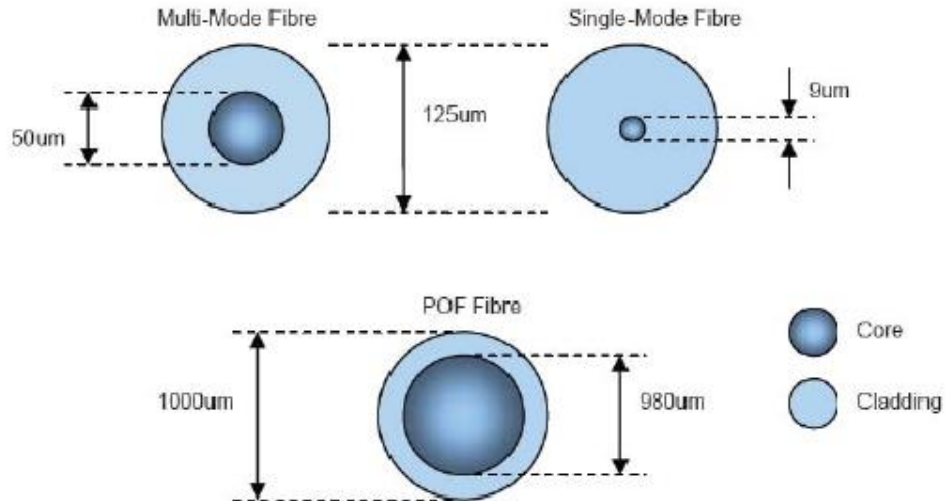


Figure 3: Single-Mode, Multi-mode and POF Fiber Core / Cladding Diameters

Standard fiber-optic cables have a glass quartz core and cladding, where impurities are added to the core to produce the desired refractive index to act a guide for the light. Glass fiber-optic cable offers lower attenuation than it's plastic counterpart. POF typically consists of a polymethylmethacrylate (PMMA) core and a fluoropolymer cladding. The plastic nature of POF provides a more rugged cable, capable of withstanding tighter bend radius than glass fiber-optic cable.

## Benefits of POF

### Why (POF) POLYMER OPTICAL FIBER

1. Less applied cost than copper and glass fiber.
2. Install labor time / cost is less, connect time is quick and reliable.
3. Optical POF switch is low power, quite requires no mechanical air flow fans.
4. Requires less infrastructure support from up stream High Speed Switches and Routers. Cost savings requiring fewer physical ports.
5. 50 % less power to operate vs copper.
6. 80 % reduction of CO2 vs copper.
7. Secure robust reliable data transfer.
8. Not subject to cross talk interference.
9. Immunity to electromagnetic interference.
10. Eye-safe visible red light, troubleshooting is quick and easy.
11. POF is light weight excellent toughness and durability, bending free and easy and easy disposal.



12. Water proof, moisture proof, free of magnetic and free of lightning strikes.

13. Green technology, in some states there are tax advantages to have the technology in the building and is certified by LEED (Leadership in Energy and Environmental Design) or GBCI (Green Building Certification Institute). Both systems were developed by the USGBC U.S. Green Building Council.

## ELII products for Home networking

ELII (Electronic Links International Inc.) products connect to the standard off shelf industry standard intelligent switches and routers normally found in IT Network rooms.

ELII brings optical communications to the desktop at the suite and room level with:



1. 8 Port Optical POF Switch (Layer 2)
2. POF – Polymer Optical Fiber, in the wall.



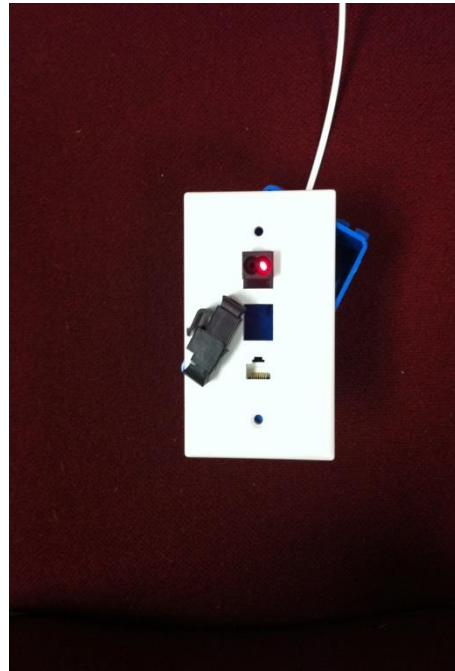
3. Optical Kit



4. Optical Converters



5. Feed thru adapter



6. With wall plate



7. USB PCI converters



## A typical Suite Design Floor plan for Optical POF Wire and Wireless solutions

With one POF line drop per room, the end user gets three active connections. Example, for a 4 bedroom suite with a 1 living room, five POF lines would service 15 RF45 connections. The copper solution; 15 Cat 6e lines would be dropped to service the same number of ports and a larger router would have to be installed.

Each Suite gets one POF service line with 3 RJ45 connections per Bedroom and Living Room, 1 optical POF 8 port switch. The Wall Plate are located near the desk in the bedroom and one near the entertainment center in the living room. The Wireless Cisco Aironet Clean Air products are placed in common area locations of a common hall outside the Suite to service multiple Suites.

### Sample drawing - 3 Bedroom 3 Bathroom



Figure 4: Typical Suite

Four POF lines service 12 RJ45 connections, 1 optical POF switch (located in utility room with a D-mark 1 Gig line).

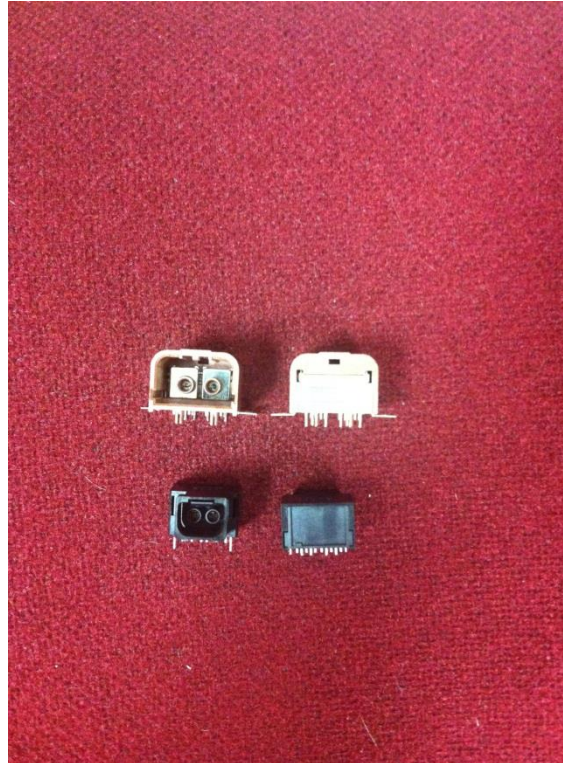
The recommend infrastructure is Optical POF in the Suite, 1 Gig D-mark to the Suite using copper Cat 6a, and Cat 6a 10Gig from Main IT Network Room to IT Network Rooms, and for the Wireless Access Points Cat6e for POE connections.

## **ELI products for industrial, medical, automotive and avionics**



8. Adapter (Industrial sensors)





9. Optical connectors and mating cable assemblies for medical and auto



10. Optical connectors for avionic application